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Connection Between Non-Linearity of the Pomeranchuk Trajectory and An Intercept Below 1

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ABSTRACT

An order of magnitude relation is suggested between the curvature of the Pomeranchuk trajectory and the displacement of its intercept below 1.

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Experimental evidence has recently been reported for curvature of the Pomeranchuk trajectory.[1] For t in the range $0.05\ \mathrm{GeV}^2 < |t| < 0.10\ \mathrm{GeV}^2$, the slope has an average value of $0.37 \pm .08\ \mathrm{GeV}^{-2}$, while for $0.10 < |t| < 0.30\ \mathrm{GeV}^2$ the average slope is $.10 \pm .06\ \mathrm{GeV}^2$. Such behavior has been qualitatively anticipated from the multiperipheral model as a consequence of interaction between the leading pole and the leading branch point.[2] We here present a simplified description of this pole-branch point interaction which allows an immediate order of magnitude estimate of the displacement of the Pomeron intercept below 1. We avoid the detailed model-dependent considerations of Ref. 2 which tend to obscure the essential elements of the mechanism.

The source both of the curvature of $\alpha_P(t)$ and of the displacement of $\alpha_P(0)$ below 1 is the Finkelstein-Kajantie requirement of a non-vanishing interval between pole and branch point.[3] The argument of these authors establishes such a gap only at $t = 0$, but the multiperipheral model extends their argument to make plausible that the pole and branch point are not allowed to intersect for any real negative t.[2] The magnitude of the separation between pole and branch point is model-dependent, but at $t = 0$ the branch point position is related to that of the pole by the formula

$$\alpha_c(0) = 2\alpha_P(0) - 1, \tag{1}$$

so the gap width

$$\Delta \equiv \alpha_P(0) - \alpha_c(0) \tag{2}$$

is also equal to $1 - \alpha_P(0)$, the displacement below 1 of the Pomeron intercept. How do we infer curvature of the trajectory?

We may infer curvature from the circumstance that if the pole trajectory were linear, the branch-point trajectory would also be linear and with half the slope, because*

$$\alpha_c(t) = 2\,\alpha_P(t/4) - 1. \tag{3}$$

Since the branch point lies beneath the pole at $t = 0$, an intersection at some negative value of t would be inevitable. To avoid intersection with the branch point the trajectory must develop positive curvature.

We are now in a position to make an order of magnitude estimate. With no curvature, and a slope α_P', intersection would occur at

$$\bar{t} = \frac{2\Delta}{\alpha_P'(0)} \tag{4}$$

To avoid intersection the trajectory slope must decrease by about a factor of two in going from $t = 0$ to $t = \bar{t}$. The recently acquired ISR data[1] suggests that the order of magnitude of $\bar{t}$ is 0.1 GeV^2, while $\alpha_P'(0) \approx 0.4$ GeV^{-2}. Thus from Formula (4) we estimate

$$\Delta = \frac{\alpha_P'(0)\,\bar{t}}{2} \approx .02 \tag{5}$$

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*Formula (3) is valid only for linear trajectories, while Formula (1) is general.

Such an order of magnitude for $1 - \alpha_P(0)$ was also estimated in Ref. 2 on a more model-dependent basis that did not employ any experimental information about trajectory curvature.

The estimate $\Delta \approx .02$ is on the upper extreme of what can be tolerated from total cross section measurements, since the asymptotic Regge prediction is that

$$\sigma_{tot} \propto s^{-\Delta} = e^{-\Delta \ln s} \tag{6}$$

The interval in ln s between CERN-Brookhaven-Serpukhov conventional measurements and ISR measurements is about 4; thus we expect the fractional decrease in σ_{tot} over this interval to be $\approx 4\Delta$. From available proton-proton total cross section measurements[1] the upper limit for such a fractional decrease seems to be about .08 (3 mb out of 40 mb), indicating that Δ is no larger than .02.

If total cross sections turn out to increase asymptotically with energy as suggested by some interpretations of cosmic ray evidence,[4] the picture presented here must evidently be discarded.

Abarbanel et al., have used the multiperipheral model to suggest an order of magnitude equivalence between the displacement Δ and the dimensionless triple-Pomeron coupling η_P.[5] Experimental upper limits on η_P are so far extremely crude but lie in the range .005.[6] However a recent Deck model calculation by Sorensen estimates $\eta_P \approx .0004$.[7]

Were the displacement Δ of such a small magnitude it would probably never be detected in total cross section measurements. Furthermore, the connection suggested here between the order of magnitude of Δ and the reported curvature of the Pomeron could not be sustained.

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